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THE CORN EARWORM AS AN ENEMY OF FIELD CORN IN THE EASTERN STATES

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THE CORN EARWORM [2] is the most destructive insect enemy of ear corn in the United States. It occurs throughout this country wherever corn is grown, but is most destructive in the Southern States where the breeding season is longer and where its most important secondary host plant, cotton, is grown in abundance. Sweet corn is especially attractive to the earworm. Even in the North the losses to this crop are heavy, whereas in the South production was practically impossible until the recent development of methods of control with insecticides. Field corn is not so severely injured; nevertheless, it has been estimated that at least 2 percent of this crop is destroyed annually by the earworm. In a single year the earworm has caused an estimated loss of $75 million to the corn crop in the United States.

Although corn is its favorite food, the earworm is also an important enemy of several other crops. On cotton it ranks next to the boll weevil in amount of damage done. When feeding on cotton it is called the bollworm. Under the name "tomato fruitworm" it is a very destructive enemy of early tomatoes in the Southern States and in California. The late broods attack the buds and seed pods of tobacco and feed also within the pods of green beans, lima beans, and soybeans. Heads of grain sorghum often are severely injured. The larvae prefer to feed upon the grain or fruits of the plants, but when these are not available they may devour the leaves. On vetch, for example, the earworm assumes migratory habits similar to those of the armyworm. Peanut foliage is frequently injured in the Southeastern States, and alfalfa is sometimes attacked, especially in the irrigated sections of the Southwest.

The earworms also feed on many other plants, some of which are cowpea, okra, sunflower, Chinese cabbage, lettuce, spinach, castor bean, squash, and green peppers.

HOW CORN IS DAMAGED

The damage to corn is caused entirely by the worms, or larvae.

[1] Entomologists W. J. Phillips and G. W. Barber contributed materially to the information presented in this bulletin. Research on resistance of field corn to the corn earworm has been conducted cooperatively by the Bureau of Entomology and Plant Quarantine, the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the State agricultural experiment stations of Illinois, Indiana, Louisiana, and Mississippi.

[2] *Heliothis armigera.*

Figure 1.—Corn eorworm injury to bud (at left) and tossel (ot right) of corn. Reduced nearly one-holf.

In carly plantings they attack thc buds or central shoots, feeding on thc tender unfolding leaves. When these injured leaves unfold, they present a ragged appearance, which is often called ragworm or budworm injury. Usually such damage results only in slightly reduced yields, although occasionally the plants are badly stuntcd and produce little grain. When tassels appear, the worms immediatcly attack thcm, but this fceding rarely causes serious injury (fig. 1.).

When the silks and ears appear, the larvae desert all other parts of the plant and turn to them. Newly hatched larvae crawl to the tip of the husk, push their way in between the silk strands, and start to feed (fig. 2). Corn silk is an attractive food for the larvae only while it is fresh; after it dries out the larvae feed upon the developing kernels.

Figure 2.—Partly grown eorworm severing fresh silks before fertilizotion of the eor is complete.

The worms may become full grown upon silk alone if the husk is long and fits tightly about the silk. If the husk is short and fits loosely about the ear, the worms start feeding at onee upon the exposed kernels. The prineipal injury oeeurs when the worms reaeh the ears. Many of the kernels are destroyed while still soft. As the kernels harden, the larvae burrow under them, feeding on the germ parts (figs. 3 and 4), whieh remain soft

Figure 3.—Eor of corn showing serious eorworm injury. Note obundont excrement where o lorge number of kernels hove been entirely destroyed while soft; olso portly visible eorworm still feeding in the germ part of the hardened kernels. Slightly enlarged.

Figure 4.—Injured eor typicol of results of germ feeding by earworm. Note missing kernels.

longer. Such kernels drop out during husking and handling (fig. 5) and are lost.

Figure 5.—Hardened kernels with germ portions destroyed by earworms. Such kernels drop from ears during handling and represent serious loss.

INJURY BY OTHER ORGANISMS AFTER EARWORM FEEDING

The indirect injury caused by the earworm is sometimes as important as the direct loss. Molds that would not otherwise gain entrance to the ear are carried in by the worms, or enter with rain through holes in the husk (fig. 6) bored by earworms or at the tip where silks severed by the worms have fallen out. Within the ear, molds breed upon the mass of excrement and damaged kernels left by the worms, and often destroy many of the remaining uninjured kernels. Ears severely injured by molds are unsafe to use for feed, especially for horses. Other insects, such as the grain beetles and weevils, that are unable to penetrate sound, long, tight husks, often gain admission to the ears through husks or silks injured by earworms. In the far South they cause considerable damage.

OTHER INSECTS CAUSING SIMILAR INJURY TO CORN

Several other insects injure the buds of young corn. Among these are the southern cornstalk borer,[3] the adult of the southern corn rootworm,[4] the stalk borer,[5] and the fall armyworm.[6] The ears of late corn also are frequently attacked by larvae of the fall armyworm, and occasionally a cutworm makes its way to the ear. The corn earworm can be distinguished from these other larvae, however, by the presence of conspicuous stripes that run the full length of the body.

[3] *Diatraea crambidoides.*
[4] *Diabrotica undecimpunctata.*
[5] *Papaipema nebris.*
[6] *Laphygma frugiperda.*

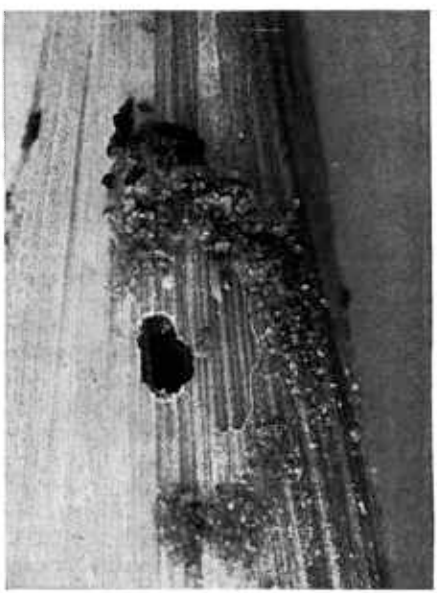

Figure 6.—Hole made by earworm boring its way out of the husk. Such openings afford entrance to rain, molds, and weevils.

The European corn borer [7] commonly feeds in the ears of corn, causing injury similar to that of the earworm. The larvae of this insect are brown or pinkish and about an inch long when full grown. They feed throughout the plant—in the tassel, stalk, husk, ear, and cob. Feeding often starts in the tassel, which frequently breaks over, and the larvae burrow downward in the stalk. The corn borers pass the winter as larvae in the cornstalks, where they pupate and produce moths the following May and June, whereas the corn earworms pass the winter as pupae below the surface of the soil.

STAGES OF THE EARWORM

The corn earworm passes through four stages—the egg (fig. 7), the larva or worm (fig. 8), the pupa (figs. 9 and 10), and the moth or adult (fig. 11). However, few growers are familiar with it except when the partly grown worm is feeding voraciously in the ear.

Figure 7.—Eggs of earworm on corn leaf. Enlarged.

If the leaves are carefully examined in the spring, a few eggs may be found. Later, when the silks begin to appear, the eggs are more easily detected, because large numbers are often laid on the silks of a single ear (fig. 12).

Egg

The egg is about half the size of the head of a common pin. It is shaped like a flattened ball and is ribbed. When first laid it is a light yellow, but it appears white against the dark green of the corn plants. It soon darkens and when ready to hatch has become a dusky brown. Hatching occurs from 2 to 8 days after the egg is deposited, depending on the temperature.

Larva

The newly hatched larva is whitish with a black head, and is very small. Growth is rapid. The worm attains full size in 13 to 28 days after hatching. The increase in size is accomplished by the process known as molting. Every 2 to 5 days the old, hard skin is split down the back and cast off, and the worm expands greatly before the new skin has become hardened. Five such molts usually occur during the process of growth. Each molt is preceded by an inactive period of several hours.

When full grown the earworm is about 1½ inches long and very robust. The coloration at this time varies greatly. Many of the larvae are marked with conspicuous stripes of varying shades of cream, yellow, brown, slate, and black. A few are without stripes and may be pink, green, cream, or yellow.

The larval stage is the only destructive stage of the insect. When one has become acquainted with the habits and general appearance of the earworm, he will not easily confuse it with any other insect found on corn. The best way to become familiar with the larva is to open several ears of infested corn in midsummer and examine the larger worms.

[7] *Pyrausta nubilalis.*

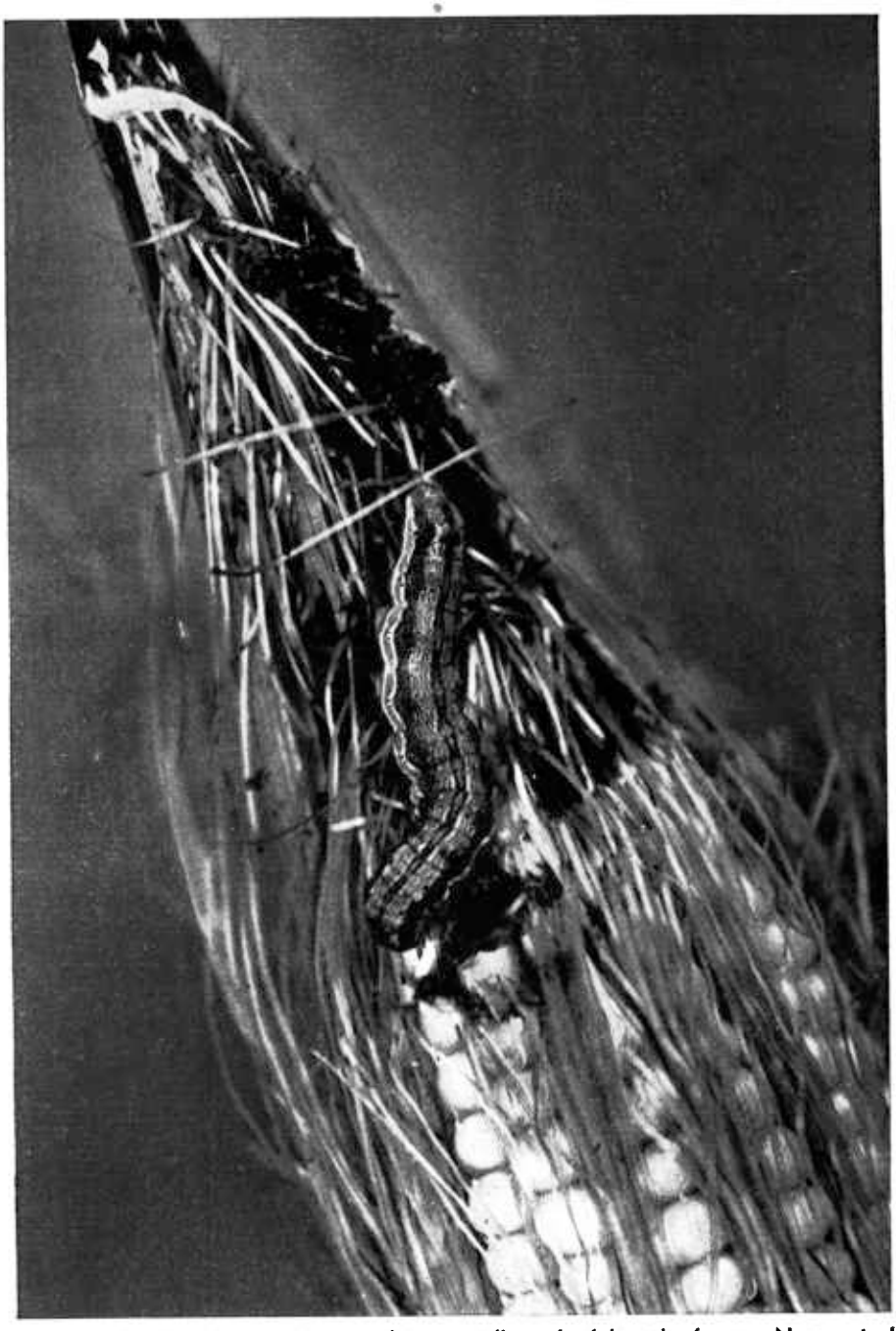

Figure 8.—Nearly full-grown earworm devouring silks and soft kernels of corn. Note typical striped appearance of the larva. Enlarged.

Figure 9.—Pupa of the earworm in its burrow in the soil. Note the channel constructed for the escape of the moth.

Pupa

When full grown the larva leaves the ear, usually by boring out through the husks (fig. 6), and drops to the ground. It enters the soil as soon as possible, and bores down 1 to 9 inches, depending on the hardness and moisture content of the soil, and weather conditions. The larva then forms a cell (fig. 9) and a passageway from the cell to within about ½ inch of the surface through which the moth can emerge, and then the larva returns to the cell, where it transforms into a light-brown pupa about ¾ inch long. While in the pupal stage it changes to the moth. When the change is complete, the moth emerges and makes its way to the surface, where the wings expand and harden.

In midsummer the period from the time the larva leaves the ear until the moth emerges may be as short as 14 days. It is usually somewhat longer, and it may be several months, as the insect passes the winter in the pupal stage.

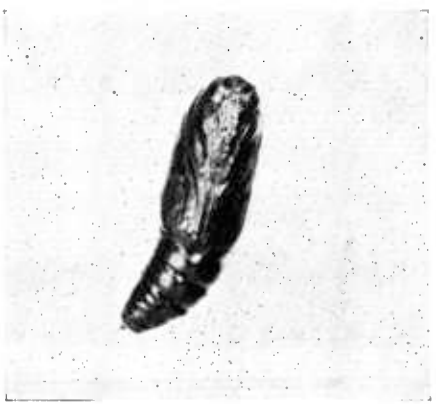

Figure. 10—Pupa of the corn earworm. Enlarged.

Figure 11.—An earworm moth resting on corn leaf. Slightly enlarged.

Moth or Adult

The moth is about ¾ inch long and has a wingspread of 1½ inches. The coloration is dull, from a light olive green to a rather dark reddish brown. Although it is not strongly attracted to lights, it is similar to moths that are common about lights in the summer. The grower may seldom see one, except at midday resting in the central shoot or bud of a corn plant. The moths become active early in the evening, feed on

the nectar of various flowers, and then fly in search of suitable plants on which to lay their eggs.

Each female moth deposits many eggs in an evening, distributed over a number of plants. The eggs are laid singly, but many may be laid on one plant before another is visited. The females live about 12 days, and each may deposit between 400 and 3,000 eggs, the average being about 1,000.

Figure 12.—Ear of corn in full silk, at the stage when it is most attractive to the earworm adults for egg laying. Note the large number of eggs scattered through the silks.

SEASONAL HISTORY

The egg, larval, and pupal stages of the corn earworm are shorter in hot weather than in cool weather. In hot weather the full life cycle can be completed in a month.

The insects develop rapidly throughout much of the year in areas with a very mild climate such as southern Florida, parts of States bordering the Gulf of Mexico, and southern California. There may be as many as seven generations a year in some of these southern areas. In the most northern part of the country, however, there is usually only a single generation each year. Throughout the greater part of the Corn Belt there are three or four generations annually. The number of generations largely determines the destructiveness of this pest in any given area.

In the northern part of the country the earworm is unable to survive the winter under ordinary conditions. In the East pupae do not usually survive much farther north than a line from central Virginia through St. Louis, Mo., to Topeka, Kans. Along the Pacific coast, on the other hand, pupae survive in low elevations at least as far north as southern Washington. During mild, dry winters the pupae may survive in sandy soils or in protected areas north of these latitudes.

But when a mild, dry winter is followed by a hot summer, the earworm is destructive much farther north than otherwise. The moth also migrates or is carried by winds long distances northward during the summer. Such migration is most common when corn and other crops in the South are suffering from heat and drought.

In the northernmost latitudes where earworm pupae survive the winter, the moths start emerging the last part of May or the first week in June. Their eggs, which begin the first generation of the year, are most abundant during the last of June and the first 2 weeks in July. In the last part of July or the first part of August there is usually a period when few or no eggs can be found. Moths of the first generation soon appear, however, and eggs are deposited in greater abundance than before. These eggs begin the second generation. From this time until frost eggs can always be found, the broods overlapping, though the eggs are more abundant at some periods than at others.

The earliest moths of the second generation appear during the last part of August and lay the eggs that begin the third generation. In Virginia it is this generation which passes the winter in the pupal stage.

Farther south the moths appear in abundance earlier in the spring. In the Lower Rio Grande Valley of Texas, for example, they infest large acreages of sweet corn as early as the last week in March. In other areas in the South the moths appear from April to early May and attack corn, vetch, tomatoes, and other early crops. The later generations develop on late corn, cotton, and tobacco.

NATURAL LIMITING FACTORS

Natural factors limit the abundance of the earworm so that rarely more than two or three larvae survive to maturity upon a single ear of corn. Were it not for this natural control, injury to the crop would be many times greater.

Cannibalism

The most important factor helping to reduce earworm damage to corn is the earworm's habit of cannibalism. Whenever two worms come into contact with each other, they fight until one or both are injured

beyond recovery. If one survives, it will often consume its foe. Since most of the newly hatched worms enter the ears through the silks, contact is very frequent and only a few worms survive to reach the kernels. Scores of larvae sometimes enter ears, but few survive because of this cannibalistic habit. This is especially true where husks are long and tight, because the silk channel of such husks is long and narrow and the larvae come into close contact with one another. When husks are short or loose, worms easily find their way to various parts of the ear without feeding much on the silk or disturbing one another. When thus widely separated they feed unmolested and many more reach maturity. A few worms enter the ear by boring through the husk.

Parasites and Predators

A tiny wasplike insect known as *Trichogramma minutum* is the most important egg parasite. Although it is usually present in the cornfields, it varies greatly in abundance. In some seasons in southeastern United States fully 90 percent of the earworm eggs fail to hatch because of the work of this insect. It is not so important in other regions. This parasite also attacks the eggs of many other injurious insects.

Earworms feeding upon the ears of corn are fairly well protected against parasites. However, when they feed upon such plants as vetch and alfalfa, they are easy prey to several parasites, particularly the two-winged fly *Winthemia quadripustulata*.

The earworm pupa is formed within the soil and therefore is practically secure against parasites.

The most important predatory insect enemy of the earworm egg and small larva is a small blackish bug, *Orius insidiosus* (fig. 13),

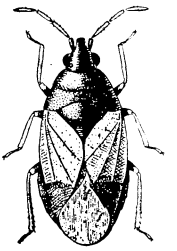

***Figure 13.*—Adult of *Orius insidiosus*. This bug destroys large numbers of eggs and young larvae of the earworm. Enlarged.**

about 1/16 inch long. Although these bugs occur on many species of plants, they are perhaps most abundant on corn. The bugs deposit their eggs on the silks. The reddish nymphs that hatch from these eggs feed on the silks. They destroy many earworm eggs and young larvae by puncturing them with their beaks and sucking out the contents. Sometimes as many as 25 of these bugs may be found on a single corn plant.

At least 21 species of birds feed on the corn earworm. Most important are the Brewer's and California red-winged blackbirds, the boat-tailed grackle, the English sparrow, and the downy woodpecker. In some areas, particularly in the South, birds may seriously damage corn, especially sweet corn, by tearing open the husks in search of earworms (fig. 14).

Moles destroy many corn earworm pupae. Late in the season cornfields may be noticed in which

mole tunnels branch out in all directions.

Figure 14.—**Undesirable corn husk characters. Note bird injury to exposed tip. Ears having short or loose husks are especially susceptible to earworm injury.**

Weather

The weather has an important effect upon the earworm throughout its seasonal history. Summer storms limit the abundance of the insect. The wind and rain dislodge many eggs, which fall to the ground and are destroyed. The first frosts and freezes in the fall kill all larvae that are not well protected. Large numbers of hibernating pupae die in the soil from cold and excess moisture. In central Virginia not more than 5 or 6 percent of the larvae that enter the soil in the fall survive to emerge as moths the following spring. Mild, dry weather is favorable to the insect.

Disease

During prolonged periods of wet weather large numbers of larvae die within the ears of corn as a result of certain diseases. Many more die from similar causes after they enter the soil to pupate. Many pupae die of disease in the hibernation burrows. The young larvae are rarely affected in this manner.

CONTROL MEASURES

The corn earworm is of such general occurrence and has been known as a pest for so long that the farmer, especially in the Southern and Central States, has come to look upon its presence as an inevitable consequence of corn planting. Although there is yet no adequate means of control on the large acreages of field corn grown in this country, farmers can profit from recent progress made toward the reduction of damage by the pest. Fertilization, crop rotation, the use of legumes, and other measures that make the land more productive aid in reducing earworm injury.

Time of Planting

The time at which field corn is planted affects the severity of earworm damage. In general, in the North Central and Northeastern States the earliest planted corn is injured the least and the latest is damaged most severely. However, throughout this area the European corn borer is a problem and unusually early planting encourages infestation by that insect. It is recommended, therefore, that corn be planted at the usual time for the locality.

In the Southern States, where the European corn borer is not widespread, early planted corn is more likely to be infested by the earworm because the moths concentrate their egg laying in such fields. Late-planted corn is also severely damaged. Corn planted at the usual time, when this is consistent with good agronomic practices for the locality, comes into silk when cotton and other plants are also attractive to the earworm moths and thus fewer eggs are laid on corn.

Planting Resistant Hybrids

Several hybrids now on the market carry some earworm resistance, especially in the South. Dixie 18, a yellow dent corn hybrid which is adapted to most of the Southeastern States, has considerable resistance to the earworm and also to the rice weevil. In addition, several well-adapted white hybrids in production in the Southeast—Dixie 11, Georgia 281, and Louisiana 521—possess some earworm and rice weevil resistance. These hybrids have been developed through the cooperative efforts of research workers in the Southern Corn Improvement Conference. In Texas the yellow hybrids Texas 24 and 30 and the white hybrids Texas 9W and 11W are reported to possess some earworm resistance.

A tight husk extending at least 2 inches beyond the tip of the ear is characteristic of hybrids so far found resistant to earworm damage (fig. 15). Resistant hybrids with good husks may be damaged less than one-fourth as much as more susceptible strains with poor husks. Any hybrid grown in the South which has a husk that does not completely cover the end of the ear is liable to damage, not only by the corn earworm, but by the rice weevil, birds, weathering, and diseases.

Farmers should contact their county agent or State agricultural experiment station for the latest information on corn hybrids resistant to the corn earworm and adapted to their particular locality, and the best time for planting.

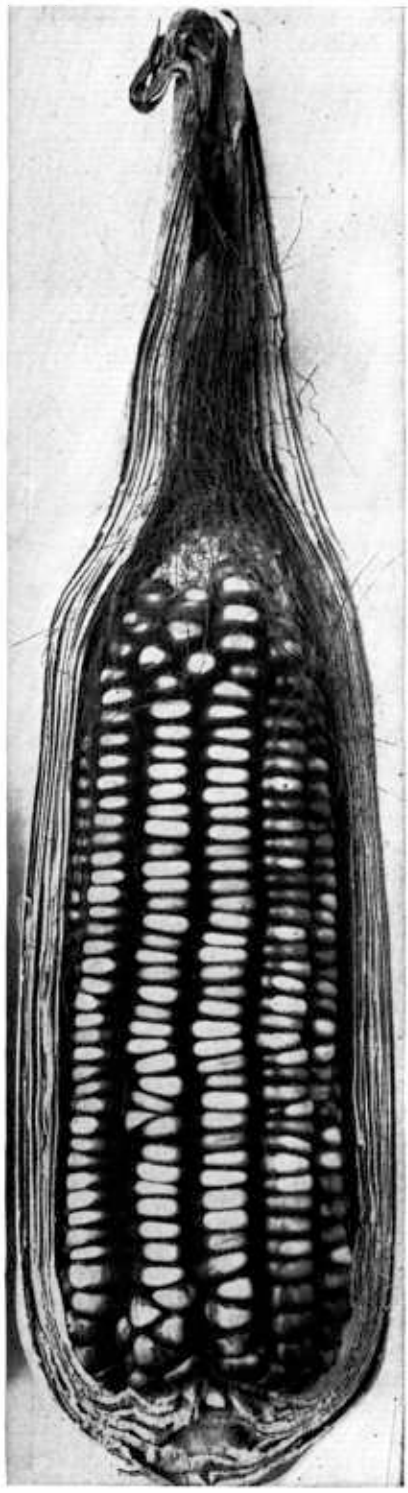

Figure 15.—**Desirable husk characters. Protection like this will greatly reduce both earworm and weevil injury.**

Control in Seed-Corn Fields With Insecticides

Usually it is not practical to use insecticides for control of the corn earworm in field corn. However, this method of protecting the ears may be desirable in the case of valuable seed corn, such as inbred lines or single crosses, which often are not so resistant as the double-cross hybrids grown generally by farmers. Occasionally, when weather conditions favor early infestation of the earworm in the more northern areas, large acreages of seed corn are seriously damaged. Methods of control suitable for both small- and large-scale application are now available.

For small-scale application use an oil solution of DDT. Such a solution should contain 1½ pounds of DDT in 25 gallons of white mineral oil having a viscosity of 65 to 95 seconds Saybolt at 100° F. Apply a fine spray to the individual ears with a knapsack sprayer, a spray gun, or a power sprayer with hose and nozzles for hand application. Use only enough to wet the silks—not more than ¼ teaspoonful—and make only one application, 5 or 6 days after the silks appear. If the insecticide is applied earlier the ears may not be properly fertilized and will be poorly filled.

For protecting large acreages of seed corn use a DDT emulsion. Mix 3 gallons of 25-percent DDT emulsifiable concentrate and 7 gallons of white mineral oil having a viscosity of 65 to 95 seconds Saybolt at 100° F. with water to make 100 gallons. Make two or more applications at the rate of 25 gallons per acre with a high-clearance sprayer having four nozzles per row that produce a fine spray. Adjust the nozzles so that the spray hits the ears. Make the first application not later than 2 days after the silks appear. If you are to make only two applications, make the second one 3 days later, but if you are to make three applications reduce the interval to 2 days. This spray will not affect fertilization or filling of the ears.

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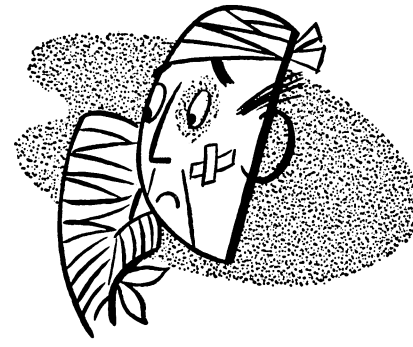
Farm Accidents Each Year . . .

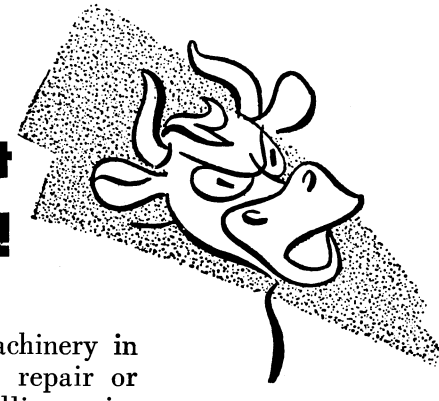


Kill about 15,000 people.

Injure or cripple about 1¼ million more.

Cause loss of 17 million man-days of farm labor, or the services of 46,000 men working every day for a year.

Help Prevent Most of These Accidents!



Keep tractors and other farm machinery in good repair. Equipment in bad repair or carelessly handled ranks first in killing or injuring farm people.

Handle bulls and other farm animals carefully. They rank second in causing farm accidents and deaths.

Use sharp-edged tools with caution—sickles, saws, corn knives, chisels, screwdrivers, axes.

Take proper care in using, handling, and storing insecticides and other poisonous chemicals.

Install, use, and repair electrical appliances and equipment properly.

You can lessen the seriousness of many accidents by immediate and proper care. Keep a first aid kit handy and know how to use it. **Call a doctor.**